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Buriti (*Mauritia flexuosa* L. f.) fruit by-products flours: Evaluation as source of dietary fibers and natural antioxidants

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ABSTRACT

Buriti by-products flours were evaluated as sources of dietary fibers and natural antioxidants. All flours presented chemical characteristics that allowed classification as high dietary fiber powders. Presence of pectic polysaccharides, arabinoxylans and xyloglucans was inferred by the neutral monosaccharides profile. Peels and defatted pulp flours are highlighted as those with higher antioxidant potential (total extractable polyphenols and antioxidant activities by DPPH and FRAP) compared to endocarp and manually-produced bran flours. Carotenoids content were also higher in the peels flours. All produced flours showed expressive amounts of total non-extractable proanthocyanidins (NEPA). Buriti peels flours NEPA levels are among the highest values previously described in the literature. Blanching preserved the extractable polyphenols but not carotenoids or NEPA. Technological properties were influenced mainly by the size of the particles. Buriti by-products flours have potential to be used as sources of dietary fiber and natural antioxidants in food.

1. Introduction

Buriti (*Mauritia flexuosa* L. f.), from the *Arecaceae* family (Fig. 1), is a fruit native to South America, and over 10,000 tons are produced yearly in Brazil (IBGE, 2018). It is a small fruit, of the size of a plum, with reddish brown peel and a thin layer of yellow pulp, which is consumed in the processed forms of sweets, ice creams, juices, jams and wine (Sampaio & Carrazza, 2012). The fruit pulp has been reported to present significant levels of total phenolics and carotenoids as well as high antioxidant capacity (Candido, Silva, & Agostini-Costa, 2015). The fatty acids and beta-carotene types and contents in the oil extracted from the pulp are considered relevant for applications in the pharmaceutical and cosmetics industries (Garcia-Quiroz et al., 2003).

Industrial extraction of the oil generates residues such as peels (~2500 tons/year), endocarp and pulp bran (~6000 tons/year). Local producers also extract the oil directly from the fruit, generating a residue, namely manually-produced bran (MB). These residues are either discarded or used by local artisans (baskets, furnitures, toys, etc.) or as animal feed (Sampaio & Carrazza, 2012). However, they present a potential use for human food, since they can be viewed as sources of dietary fiber and antioxidant compounds. Ayala-Zavala et al. (2011) argue that exotic fruit by-products can present higher contents of bioactive compounds (e.g. dietary fiber, phenolic constituents and carotenoids) than the edible portion of the fruits, and that these by-products could be used by the food industry as colorants, texturizer additives, antimicrobials, flavoring and antioxidants, in the control of lipid oxidation and as functional food ingredients. Saura-Calixto (1998) commented that dietary fiber from fruits are better than dietary fiber from cereals, because they contain more associated bioactive compounds, better soluble/insoluble fiber ratio and higher fat retention capacity, with lower energy value. Fruit by-products have been extensivelty identified and characterized as potential food ingredients, sources of dietary fibers and bioactive compounds. Examples include grape peels (Saura-Calixto, 1998), pequi peels (Leão, Franca, Oliveira, Bastos, & Coimbra, 2017) and others. However, even though fruit by-products are produced worldwide in large quantities and have been already established as rich sources of functional compounds, they are also scarcely profitably exploited, with only a handful of by-products such as citrus peel, tomato waste and apple pomace being currently industrially processed (Galanakis, 2012).

Fiber-rich flours produced from fruit by-products are an ingredient that can be added to different food products, improving the nutritional value and properties of processed foods. Food fibers can influence hydration, solubility and viscosity properties of foods. Also, they contribute to slow glucose absorption, to decrease total cholesterol and LDL, to stimulate intestinal fermentation and production of short chain fatty acids, among other functions (Dhingra, Michael, Rajput, & Patil, 2012). Furthermore, dietary fibers from by-products of fruits that are

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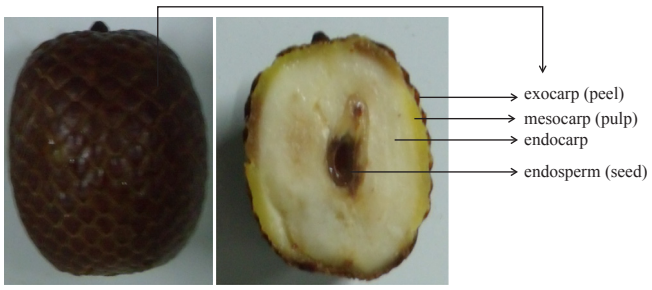

Fig. 1. Buriti fruit (*Mauritia flexuosa* L. f.).

rich in antioxidants usually present high levels of polyphenols and carotenoids, thus combining the beneficial effects of both dietary fiber and antioxidants, e.g., antioxidant dietary fiber (Leão et al., 2017).

Different studies are found in the scientific literature about the buriti fruit, oil and pulp (Candido et al., 2015; Cordeiro, de Almeida, & Iacomini, 2015; Medeiros et al., 2015; Lima et al., 2017; Milanez, Neves, Colombo, Shahab, & Roberto, 2018), with a wide variety of applications including food (fruit, pulp), cosmetics and biofuels (oil). However, no studies were found on the nutritional potential of buriti processing by-products. Thus, the hypothesis of our study is that buriti by-product-based flours can be considered potential sources of antioxidant dietary fibers for food applications. The composition of the polysaccharide fraction of dietary fiber matrix of buriti by-product flours is characterized, together with the total phenolic and proanthocyanidin contents and associated antioxidant capacity. The technological properties of the by-product flour are also determined in order to evaluate their potential use as functional ingredient in food formulations.

2. Materials and methods

2.1. Materials

Buriti (*Mauritia flexuosa* L. f.) fruits were collected in Três Marias/Brazil, a subhumid tropical savannah area, in the Cerrado biome. The fruits were stored in boxes for seven days until complete maturation. The following chemicals were employed: acetone, butanol, hexane, hydrochloric acid, iron(III) chloride, methanol, petroleum ether and sodium carbonate (acquired from Synth, São Paulo, Brazil); alpha amylase, dichloromethane, 1,1-diphenyl-2-picrylhydrazyl radical (DPPH), dimethylsulfoxide, Folin-Ciocalteu reagent, gallic acid, 1-methylimidazole, pancreatin, pepsin, sodium borohydride, trifluoroacetic acid, and 2,4,6-Tri(2-pyridyl)-s-triazine (TPTZ) (acquired from Sigma-Aldrich, São Paulo, Brazil).

2.2. Flours preparation

The process steps are summarized in a flowchart (Fig. 2). Graded fruits were washed and sanitized. Some fruits were broken down into their constituent parts (peels, pulp and endocarp), and the seeds were discarded. Another part was destined for oil extraction by a manual process. The manual process for oil extraction was based on reports of the procedure employed by traditional extractive communities (Sampaio and Carrazza, 2012), with minor modifications. The fruits were macerated and boiled with water until the oil floated to the surface. The oil was collected and the remaining solid part (herein labled manually-produced bran) was separated. The manually-produced bran, peels, pulp and endocarp were stored at −18 °C. The pulp bran was defatted by the Soxhlet method, using hexane, as an alternative to the method of oil extracting by screw-pressing the pulp. Some of the samples were submitted to blanching (immersion in hot water at 75 °C for 3 min followed by immersion in cold water at 2 °C for 2 min).

Six different types of processed by-products were employed for production of flours: blanched peels (BP); unblanched peels (UP); blanched endocarp (BE); unblanched endocarp (UE); manually-produced bran (MB); and bran of defatted pulp obtained by solvent extraction (PB). Except for PB, the samples were mixed with water for wet-milling, and dried in a convective oven (model 420-1DE, Nova Ética, Brazil) at 60 °C for 24 h. Subsequently, the samples were ground, sieved (425-μm) and stored at room temperature in tightly sealed plastic containers. PB was already in powder form so it was just sieved and stored.

2.3. Chemical composition

Moisture, fat content, ash and proteins were analyzed according to the methodologies recommended by AOAC (1998): moisture content was evaluated by oven drying at 105 °C until constant weight; fat was evaluated by the Soxhlet method, with petroleum ether as a solvent (4.5.05); ash was quantified after incineration at 550 °C for 20 h (942.05); and protein was determined by the Kjeldahl method (960.52). Carbohydrate content was obtained by difference. Total, insoluble and soluble dietary fiber were determined by the enzymatic gravimetric method, in which the samples were digested with alpha amylase, pepsin and pancreatin enzymes (Asp, Johansson, Hallmer, & Siljestrom, 1983; Leão et al., 2017).

The neutral monosaccharides composition was evaluated by gas chromatography (Melton & Smith, 2001). The neutral sugars in the samples (5 mg sample) were hydrolysed with trifluoroacetic acid 2 mol/L (0.5 mL), reduced with sodium borohydride (1 mL, 0.5 mol/L) in dimethylsulfoxide, and derivatized with acetic anhydride (2 mL) in the presence of 1-methylimidazole (200 μL) to their alditol acetates. Dichloromethane (1 mL) was used to extract the alditol acetates. The separation of the alditol acetates was performed on a Varian 3900 gas chromatograph with flame ionization detector, through a BPX-70 capillary column (30 m × 0.32 mm × 0.25 μm; SGE Chromatography Products) and nitrogen as carrier gas (1.5 mL/min). Injector and detector temperatures were 230 °C and 280 °C, respectively. The total run time was 38 min (30 s at 38 °C, temperature increased to 170 °C at a rate of 50 °C/min, then increased to 230 °C at a rate of 2 °C/min, then maintained for 5 min).

The relation between the concentration of each monosaccharide and the peak areas of their respective alditol acetates in the chromatograms was calculated by means of the monosaccharide molar ratio relative to the internal standard used, in this case, allose:

$$RMR_{m/a} = \left(\frac{A_m MM_m}{m_m}\right)\left(\frac{m_a}{A_a MM_a}\right) \quad (1)$$

where $RMR_{m/a}$ is the monosaccharide molar ratio relative to allose, A is the chromatogram peak area, m is the mass of the sugar (g), MM is the molar mass, and the subscripts m and a represent monosaccharide and allose, respectively. The molar composition of each monosaccharide (% mol) was then calculated by

$$\%mol_i = (A_{m_i} \times 100)\left(\frac{RMR_{m_i/a}}{\sum_{i=1}^{n} A_{m_i}}\right) \quad (2)$$

where the subscript i represents a specific monosaccharide and n is the total number of monosaccharides in the chromatogram.

2.4. Total phenolics, carotenoids and in vitro antioxidant capacity

For total phenolics, DPPH, and FRAP analyses, extracts of the samples were prepared with methanol and acetone as described in the literature (Pérez-Jiménez et al., 2008), with minor modifications. The flours (1 g) were placed in test tubes, sequentially extracted with methanol (50% v/v) and acetone (70% v/v), 40 mL each. After each extraction, the mixture was centrifuged at 3500 rpm for 15 min. The supernatants were afterwards combined and the total volume completed